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MAGNETIZATION BY ROTATION[1]

So far as we know at present, a magnetic substance, that is a substance whose molecules are elementary magnets, can be magnetized in two ways, and only two ways: In the first place it can be be magnetized by creating a magnetic field in it or putting it in a magnetic field, as has been known for very many years; and, in the second place, it can be magnetized by simply setting it into rotation in a region initially neutral magnetically, and both initially and finally neutral electrically. It is chiefly with this latter process that we are concerned at this time.

In this process, as we shall see, the magnetization is produced *directly* by a sort of molecular gyroscopic action, which distinguishes it sharply from other processes in which *magnetic fields* are produced by rotation, but in which *magnetization* may or may not result, according to circumstances. It will be conducive to clearness to consider briefly some of these processes.

Thus if we take a tube of brass, or other non-magnetic substance, electrify it, and rotate it about its axis, a magnetic field will be produced similar in a general way to the field which would be produced by winding the tube with a coil of insulated wire and passing an electric current through it, as Rowland proved over forty years ago. So far, there is no magnetization. But if a rod of iron is introduced into the tube, and either maintained at rest or rotated with it, the rod will become magnetized—not because of its rotation, but be-

[1] An address delivered before the National Academy of Sciences, April 22, 1918. Most of the material presented here is taken from papers previously published in SCIENCE, the *Physical Review* and the *Proceedings of the National Academy of Sciences.* Detailed accounts of most of the work are given in the *Physical Review,* 6, 239, 1915, and 10, 7, 1917.

cause of the magnetic field, in this case produced by the rotation of the charges. There would be a similar result, and a similar interpretation, if the rod alone were to be given the charge and rotated.

Again, if we take a metal rod and rotate it in a magnetic field, electric currents will in general be induced in it; and the magnetic field due to these currents will, if the rod is made of magnetic material, change its magnetization. Experiments of this kind were made about one hundred years ago by Barlow, Christie and Arago.

In each of these cases, and in others which might be mentioned, a *magnetic field* is produced by the rotation, and it is this field which produces the magnetization if a magnetic substance is present.

Coming now to the other or gyroscopic process of magnetization, and starting with a neutral rod of iron or other magnetic substance, we can magnetize it directly by mere rotation, and a magnetic field will result from this magnetization.

In order to understand this process it is necessary to consider first, a simple case of the behavior of a gyroscope; and second, the modern interpretation of Ampère's theory of molecular currents.

Here we have a gyroscope whose wheel, pivoted in a light frame, can be rotated rapidly about its axis A. Except for the action of two springs, this frame and the axis A are free to move in altitude about a horizontal axis B, perpendicular to A; and the axis B and the whole instrument can be rotated about a vertical axis C. If the wheel is spun about the axis A, and the instrument then rotated about the vertical C, the wheel tips up or down so as to make the direction of its rotation coincide more nearly with the direction of the impressed rotation about the vertical axis C. If it were not for the springs the wheel would tip until the axes A and C became coincident. The greater the rotary speed about the vertical the greater is the tip of the wheel. When the wheel's speed about the axis A is zero, no tip occurs.

Now according to the modern version of Ampère's hypothesis, each molecule of a magnetic substance has a magnetic moment, or is a magnet, because it consists in part at least of electrons revolving in fixed orbits with constant angular velocities about an oppositely charged nucleus, and producing a minute magnetic field somewhat like that due to a small loop of wire traversed by an electric current.

If these electrons, revolving in the same general direction, have mass, each molecule has therefore angular momentum like the wheel of a gyroscope; and if the body of which it is a part is set into rotation about any axis, the molecule must change its orientation in such a way as to make the direction of revolution of its electrons coincide more nearly with the direction of the impressed rotation.

Only a slight change of orientation can occur on account of the forces due to adjacent molecules, which perform the function of the springs in the experiment with the gyroscope. The rotation thus causes each molecule to contribute a minute angular momentum, and thus also a minute magnetic moment, parallel to the axis of rotation; and thus the body, whose molecular magnets originally pointed in all directions equally, becomes magnetized.

If the revolving electrons are all positive, the body will become magnetized in the direction in which it would be magnetized by an electric current flowing around it in the direction of the angular velocity imparted to it. If they are all negative, or if the effect of the negative electrons is preponderant, it will be magnetized in the opposite direction. This is what actually happens.

For a simple type of molecular magnet a somewhat exact theory of the effect can be developed.

Assume the molecule (Fig. 1) to consist of n (one or more) similar electrons, all positive or all negative, with total charge ne and total mass nm, revolving in a circular orbit of radius r with constant angular velocity ω (and areal velocity $a = \frac{1}{2}\omega r^2$) about a much more massive, and fixed, nucleus with charge $-ne$.

This molecule will have a magnetic moment $\mu = nea$, a moment of inertia about the axis of revolution $C = nmr^2$, and an angular momen-

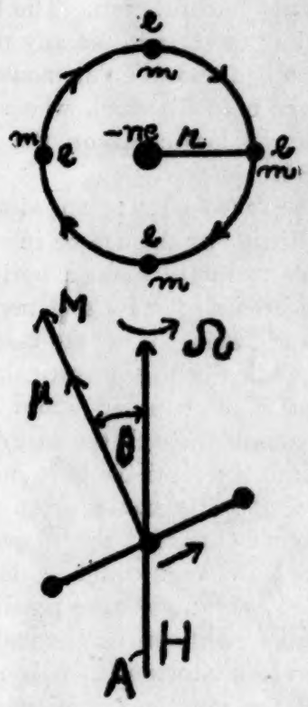

FIG. 1.

tum $M = C\omega = nmr^2\omega = 2nm\alpha$ about this same axis. The ratio of the angular momentum to the magnetic moment is

$$\frac{C\omega}{\mu} = 2\frac{m}{e}$$

The vectors representing the angular momentum and the magnetic moment are thus in the same or opposite directions according as e is positive or negative.

If now the body of which this molecule is a part is set into rotation with angular velocity Ω about an axis A, the molecule, or the orbital ring, behaving like the wheel of a gyroscope, will strive, as it were, to take up a position with its axis of revolution coincident with that of the impressed rotation; but it will be prevented from turning so far by a torque T due to the action of the rest of the body and brought into existence by the displacement. In a minute time kinetic equilibrium will be reached, and the axis of the orbit will then continuously trace out a cone making a constant angle θ with a line through its center parallel to the axis of the impressed rotation. When this state has been reached, as is known from dynamics, and as can easily be established by applying the second law of motion,[2] by Lagrange's equations, or otherwise,

$$T = \sin\theta \cdot C\omega \cdot \Omega \left(1 + \frac{1}{2}\frac{\Omega}{\omega}\cos\theta\right)$$

Now imagine the body, instead of being rotated, to be placed in a uniform magnetic field whose intensity H is directed along the previous axis of rotation, and consider a molecule whose magnetic axis, after displacement by the field, makes the angle θ with H. The

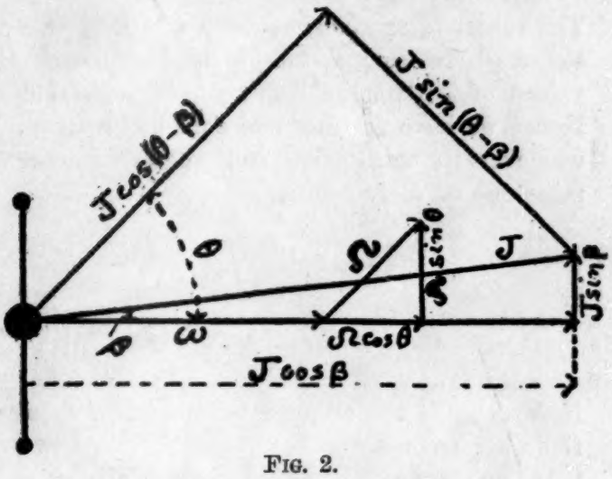

FIG. 2.

molecule would keep on turning under the action of the field until its axis coincided with H, but is prevented from doing so by the torque T' upon it due to the action of the rest of the body and brought into existence by the displacement. This torque is well known to be

$$T' = \mu H \sin\theta$$

[2] The expression for T can be found readily from Fig. 2. Let A denote the moment of inertia of the ring about a diameter, and β the angle between the vector representing J, the total angular momentum of the ring, and the vector representing ω. J can be resolved into two rectangular components, one parallel to the axis of the impressed rotation, viz., $J\cos(\theta - \beta)$, which is constant, and one perpendicular to this axis, viz., $J\sin(\theta - \beta)$, which has the constant rate of change $\Omega J \sin(\theta - \beta)$. By the second law of motion this is equal to the torque T. Expanding this expression for T, substituting for $J\cos\beta$ and $J\sin\beta$, the components of J parallel and perpendicular to the axis of the ring, their equals $C(\omega + \Omega\cos\theta)$ and $A\Omega\sin\theta$, and noting that $A = \frac{1}{2}C$, we obtain the relation sought.

To find, therefore, the magnetic intensity which would produce the same effect on the orientation of the molecule as would be produced by rotating the body at the angular velocity Ω, all we have to do is to equate T and T'. This gives

$$\mu H \sin\theta = \sin\theta \cdot C\omega\Omega \left(1 + \frac{1}{2}\frac{\Omega}{\omega}\cos\theta\right)$$

or

$$H = \frac{C\omega}{\mu} \cdot \Omega \left(1 + \frac{1}{2}\frac{\Omega}{\omega}\cos\theta\right) = 2\frac{m}{e}\Omega\left(1 + \frac{1}{2}\frac{\Omega}{\omega}\cos\theta\right)$$

The values of Ω experimentally attainable are so small in comparison with any possible values of ω that the last term is negligible. Hence we have for any molecule in the body, whatever its orientation and whether it contains one or more orbits,

$$H = 2\frac{m}{e}\Omega$$

or

$$H = 4\pi\frac{m}{e}N$$

if N denotes the angular velocity in revolutions per second.

If therefore only one kind of electricity, with fixed ratio of mass to charge, is in orbital revolution in the molecules of a magnetic body, rotating it with the angular velocity N revolutions per second is equivalent to putting it in a magnetic field of strength H, the intrinsic magnetic intensity of rotation, such that, with great precision,

$$H/N = 4\pi\frac{m}{e}$$

If we assume that negative electrons alone are in orbital revolution, the value of the second member of this equation, according to well known experiments on electrons in slow motion, is -7.1×10^{-7} electromagnetic units, and H/N should be equal to this quantity and identical for all magnetic substances. If positive electrons also participate the magnitude of H/N should be smaller.

If the Ampèreian currents consist in the motion of actual matter, so that the molecules of magnetic substances have angular momentum, an ordinary magnet or electromagnet itself should behave to some extent like a gyroscope when set into rotation. The first to see this, as well as the first to see any relation between magnetism and angular momentum, appears to have been Maxwell, who constructed apparatus for experiments on the subject as early as 1861.

In Maxwell's apparatus an electromagnet was pivoted in a circular frame in such a way as to be free to rotate about a horizontal line through its center of mass and perpendicular to its magnetic axis. With the magnetic axis making an angle θ with the vertical, the frame was rotated at high speed about a vertical axis, also passing through the magnet's center of mass, and observations were made for a change in θ, stability having been secured by suitable adjustments of the principal moments of inertia. No change could be detected, but only rough observations were possible.

In the experiments on magnetization by rotation Maxwell's electromagnet is replaced by each one of the countless multitude of molecular magnets of which the magnetic body is constituted, and the total change in the orientations of all these magnets with reference to the axis of rotation of the body is determined magnetically.[3]

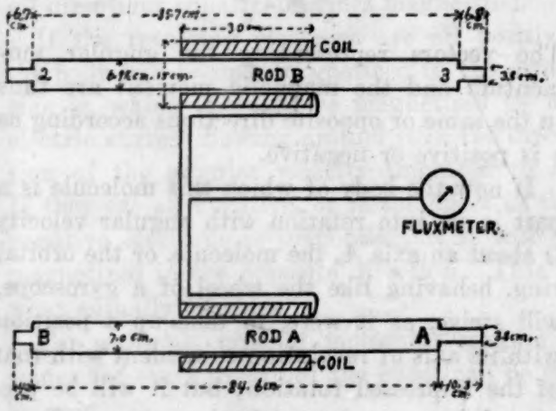

FIG. 3.

Two series of experiments have been made, both with Mrs. Barnett's assistance, and by methods as different from one another as possible. The first series of experiments was made

[3] I have learned very recently from a footnote in John Perry's *Spinning Tops* that he made experiments on this subject, with the same idea in mind, but without success, many years ago.

on large iron rods by a method depending on the principles of electromagnetic induction; the second, on smaller rods of iron, cobalt and nickel, by the method of the magnetometer. Recently a few preliminary experiments have been made on Heusler alloy.

Some of the essential parts of the apparatus used in the first investigation are shown in the diagram of Fig. 3.

Two nearly similar rods of steel shafting *A* and *B* were mounted with their axes horizontal and perpendicular to the magnetic meridian, and two similar coils of insulated copper wire were mounted about their centers. These coils were connected in series with one another and with a Grassot fluxmeter, which was the principal measuring instrument, and were oppositely wound so that that any variations in the intensity of the earth's magnetic field acting in the same way on both rods might produce no effect on the fluxmeter. One of the rods, which will be called the compensator, as *A*, remained at rest; while the other, called the rotor, as *B*, was alternately rotated and brought to rest, the change of flux being determined by the fluxmeter, which, together with the other apparatus, was standardized by proper subsidiary experiments. For use in these experiments the rods *A* and *B* were uniformly wound with solenoids of insulated wire.

To prevent possible disturbances arising from the presence of the earth's magnetic field, the rotor was surrounded by a large electric coil which approximately neutralized the earth's intensity in the region occupied by the rotor.

The rotor was directly driven in either direction at will by an alternating current motor in part of the work, and by an air turbine in the rest.

In making observations fluxmeter deflections were obtained for each of several speeds, first with the rotation in one direction and then with the rotation in the other direction.

After making a great variety of tests, and after taking many precautions to eliminate sources of error, two effects stood out very clearly as the result of the observations, instead of the one which was looked for.

If the *mean* of the two deflections for the same speed is plotted against the square of the speed, the resulting graph is a straight line as shown in Fig. 4. The *mean* deflection is thus proportional to the square of the speed. This deflection is due to the increase of the residual magnetic flux through the rotor produced by its centrifugal expansion during rotation—an effect which was not foreseen, and which was very puzzling until its explanation became apparent. This effect would vanish if the rod were completely demagnetized initially.

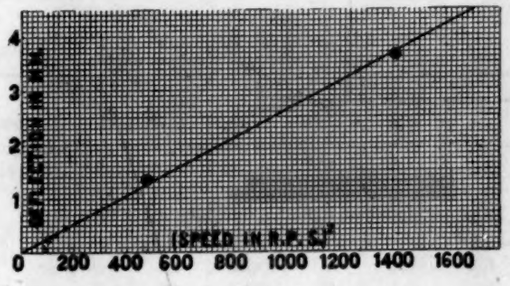

FIG. 4.

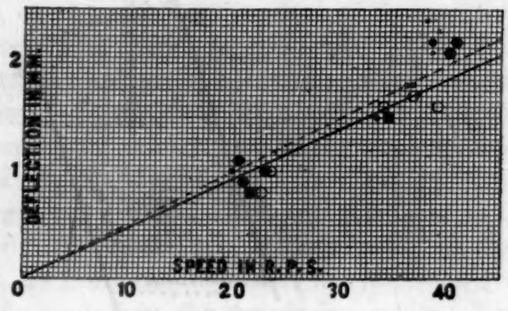

FIG. 5.

If, however, the *difference* between the two deflections for the two directions of rotation, instead of the mean deflection, is plotted against the *speed*, and not against the square of the speed, a straight line again results, as shown in Fig. 5. This is the effect which was under investigation. The straight line shows that H is proportional to N, as predicted.

The earlier experiments by this method gave for H/N the mean value -3.6×10^{-7} e.m.u.; the later and more precise experiments gave -3.1×10^{-7} e.m.u., with an experimental error for a set of four double deflections equal to about 12 per cent. The graph of Fig. 5 is drawn for these observations, the dotted

straight line corresponding to the weighted mean value of the double deflection divided by the speed.

Not long after the first conclusive experiments on magnetization by rotation were presented to the American Physical Society, Einstein of Switzerland and de Haas of Holland described successful experiments on the converse effect, viz., the production of rotation by magnetization, which had been predicted and looked for by O. W. Richardson in 1907, and they have since published additional experiments. Very recently another investigation of this converse effect has been made by J. Q. Stewart. All these investigations are indirect but excellent confirmations of the work described here.

In the second investigation, as already stated, the method of the magnetometer was used. A diagram of important parts of the apparatus is given in Fig. 6.

The rod under test, or rotor, *F*, was mounted with its axis horizontal and normal to the magnetic meridian, as in the first investigation, and in the second, or equatorial, position of Gauss, which offered great advantages over the first, or polar, position for this work.

The magnetometer system, which was astatic, is shown suspended from the torsion head *A* by a silk fiber. To reduce disturbances due to variations of the earth's intensity as much as possible, a compensating rod *B* of the same substance and nearly the same size as the rotor, was mounted in approximately the same position with respect to the upper magnetometer magnet as that occupied by the rotor with respect to the lower magnet.

Possible errors due to induced currents in the rotor and to minute shifts of the rotor's axis in altitude or azimuth were avoided by

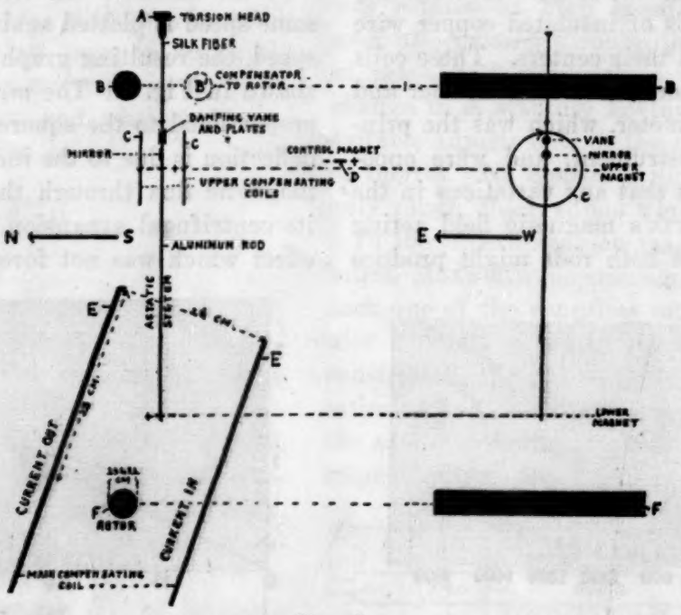

FIG. 6.

compensating accurately the earth's intensity with the large electric coil *E*, as in the earlier investigation. *C* is a small electric coil in series with *E* to make the zero and sensibility approximately independent of the compensating current in the coil *E*.

The rotors were driven by an alternating current motor, operating at the same speed in both directions. Three different speeds of the rotor could be obtained by using cone pulleys.

The principal magnetometer observations consisted in getting the double deflections produced by reversing the direction of the rotation, the speed for the two directions being the same. From these readings, the speed, and the calibration experiments, *H*, could be found as a

function of N. Numerous precautions were necessary as in the earlier investigation.

The results of the observations on four rotors are given in Table I. The "set" of observations there referred to contained four readings, or two double deflections.

With nickel and cobalt observations were made at more than one speed; and H/N was found to be independent of the speed, within the limits of the experimental error, as in the earlier experiments with iron. It is also seen to be independent of the size and shape of the body in rotation, which is an implicit requirement of the theory developed above.

TABLE I

Intrinsic Magnetic Intensity of Rotation in Iron, Nickel and Cobalt

Rotor	Series	Groups	Mean Speed R.P.S.	Number of Sets	$-\frac{H}{N} \times 10^7$ E.M.U. Mean	Average Departure from Mean (Sets)
Steel (smaller)	1	1–2	44.8	21	5.1	0.5
Steel (larger)	2	3–4	47.8	21	5.2	1.2
Cobalt...	3	5–7	20.2	17	4.8	2.2
	4	8–11	30.3	23	5.6	1.2
	5	12–25	45.5	79	6.0	0.9
	6	22	45.0	7	6.5	0.3
	7	24	44.8	9	5.9	0.4
	8	25	44.8	5	6.1	0.4
Nickel...	9	26	20.5	4	4.7	2.0
	10	27–28	30.5	9	6.7	1.1
	11	29–32	45.3	37	6.1	0.5

The value of H/N is in all cases negative, but less in magnitude than that of the standard value of $4\pi\, m/e = -7.1$ e.m.u. for negative electrons in slow motion, as was the case in the earlier experiments with iron, which gave 3.6 and 3.1 in place of 7.1. In view of the experimental errors, it still seems to me doubtful whether these discrepancies indicate definitely that in addition to the negative electrons in orbital revolution there are also positive electrons revolving in orbits. The probability of the presence of the latter orbits is great from the known expulsion of α particles with great velocities from radio-active substances. There can be no question, however, that the effect of the negative electrons is at least greatly preponderant.

A few preliminary results, not of a precise character, but consistent with those of Table I., have been obtained with a rotor of very soft iron and with a rotor of Heusler alloy—a magnetic compound of aluminum, copper and manganese in atomic proportions.

In summing up the chief results of the two investigations it may be said that, in addition to revealing a second and entirely new method of producing magnetization in magnetic substances, they have proved in a direct and conclusive way, on the basis of classical dynamics alone and without dependence on the still obscure theory of radiation, (1) that Ampèreian currents, or molecular currents of electricity in orbital revolution, exist in iron, nickel, cobalt and Heusler alloy; (2) that all or most of the electricity in orbital revolution is negative, or at least that the effect of the negative electricity is preponderant; and (3) that this electricity has mass or inertia. Furthermore, if we admit the classical theory of radiation, according to which a ring of electrons moving in a circular orbit must continually emit energy, but at a smaller rate the more uniformly the electricity is distributed in the ring, we must conclude that the electrons are closely packed in the Ampèreian orbits. For the existence of residual or permanent magnetization proves that these orbits are essentially permanent and can not therefore emit energy at an appreciable rate.

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THE ORIGIN OF THE PINK BOLLWORM

THE determination of the original habitat of the pink bollworm (*Pectinophora gossypiella* Saunders) is of great interest in relation to the present distribution of this insect and may be of importance later as indicating where parasitic or other natural checks may be found. A scrutiny of the records gives strong support to the theory that this insect originated in Southern Asia, probably India.

The first account of the insect by W. W.

Saunders[1] in 1842 accompanying its original description is based on specimens received from India, and the only information now available in relation to these specimens is an extract quoted by Saunders from a letter from a certain Dr. Barn, superintendent of the Government Cotton Plantations at Broach (Baruch) in western India. This extract is short and significant and is here given in full:

> The inclosed is an insect which was very destructive to the American cotton which was sown here (Broach), on light alluvial soil. The egg is deposited in the germen at the time of flowering, and the larva feeds upon the cotton seed until the pod is about to burst, a little previous to which time it has opened a round hole in the side of the pod for air, and at which to make an exit at its own convenience, dropping on the ground, which it penetrates about an inch, and winds a thin web in which it remains during the aurelia state. Curiously enough, the cotton on the black soil was not touched by it. The native cotton is sometimes affected by it.

This letter was addressed to a certain Dr. Royle who forwarded the specimens with this quotation from Dr. Barn to Mr. W. W. Saunders. In relation to this quotation, Mr. Saunders makes this significant comment:

> It is interesting to remark that the cotton grown from American seed is attacked in preference to any other and that the cotton plant when grown upon black soil remains free from injury. The former fact could be accounted for by the American cotton being of a different species to that usually grown in India and probably offers seeds which are more suitable to development of the larvæ.

The reason for the greater susceptibility of and damage to the American cotton is undoubtedly that suggested by Mr. Saunders and is supported by many similar experiences with introduced plants or introduced plant pests. The hardy and rather unproductive cottons of India and other southern Asiatic countries probably long associated with this insect evidently were then and are still fairly resistant to its attacks, and, on the other hand, the introduced American and Egyptian varieties are less resistant and perhaps furnish exceptional breeding conditions and were, therefore, when introduced into India and elsewhere in southern Asia, much more seriously attacked. This condition at once brought into prominence an insect which previously had been for the most part overlooked. It is significant that Dr. Barn should note that "native cotton is sometimes affected by it," indicating that it was a known but comparatively unimportant enemy of such cotton in India prior to 1842.

Saunders, in his article, makes no suggestion that the insect is other than a native Indian species, or, as has been stated by some writers, that it was imported with the American cotton. Responsibility for the theory of possible American at least African origin seems to rest with J. H. Durrant. This author, reviewing (1912)[2] the specimens of *Gelechiâ gossypiella* in the British Museum, summarizes the earlier Indian records with an evident strong mental bias toward an *inferred* American or Egyptian origin. An examination of these records indicates that there is no real warrant for this bias. Of the Indian record of 1842, quoted above, from Saunders, he suggests the importation of the insect with American cotton simply because of the excessive damage to this introduced variety in comparison with native cottons, ignoring the perfectly reasonable explanation of this condition advanced by Saunders. The records for Cawnpore (1883) and Lahore (1893–94) report damage to "cotton" but this "cotton" is *inferred* by Durrant to be Egyptian because from other sources he learned that some Egyptian cotton was being experimentally grown at or near these places and, similarly, another record from Surat, about which no information was available, is *assumed* by Durrant to have a similar history.

August Busck (1917),[3] following Durrant, without critical examination of the latter's data, accepts his general conclusions, and expresses the belief from this "evidence," and

[1] Saunders, W. W., *Trans. Ent. Soc. London*, Vol. III., pp. 284–85, 1843.

[2] Durrant, J. H., *Bul. Ent. Research*, Vol. III., Pt. 2, pp. 203–06, Fig. 1, London, 1912.

[3] Busck, August, *Jour. Agric. Research*, U. S. D. A., Washington, Vol. IX., pp. 343–70, 6 pls., 1917.

certain insect relationships which will be noted below, that Africa is indicated as the original home of the ping bollworm.

The support of this theory of African origin based on the fact that the only near relative of the pink bollworm, *P. malvella* Zeller, is known from Africa as well as Southern Europe should be given very little weight, inasmuch as a more accurate knowledge of the distribution of this related insect may show it to range, as it probably does, throughout southern Asia in addition to its now known range in Africa and southern Europe. In fact, it would be most astonishing that an insect having a range already as wide as that indicated, should not occur also in contiguous Asia, and, furthermore, entomological collections and explorations in Asia have not been made with any such thoroughness as to give this argument any substantial support.

On the other hand, Fletcher (1917),[4] reviewing the pink bollworm situated in India, states that "*Gelechia gossypiella* occurs throughout the plains of India, Burma and Ceylon, as a pest of cotton, serious in most localities, especially in the United Provinces, Punjab, and the Northwest Frontier Provinces. In all districts exotic varieties seem to be most subject to attack." He further notes that "*Gelechia gossypiella* was first described from India in 1842, and is probably endemic in India. It has since been introduced into other cotton-growing areas and has proven a serious pest, apparently worse than it is in India as a whole."

In this connection it is interesting to note that the record, as reported by Durrant,[2] indicates a wide distribution of the insect throughout southern Asia, including India, Ceylon Berma, Straits Settlements, Philippines, Japan (?) and Hawaii—records, most of them, antedating from eight to seventy years, the first report of the insect in Egypt.

Looking at the question, also, from the standpoint of cotton culture in Egypt, if it is true, as has been so strongly urged, that this insect is of African origin, and reached India from Egypt, it must follow that during the last seventy-five or one hundred years, it has had ample opportunity to demonstrate in Egypt, throughout the whole period, its maximum destructiveness. The record of the cotton crop in Egypt up to and subsequent to the first recognition of the pink bollworm in 1911 certainly gives no support to the theory of Egyptian origin; on the other hand, the evidence of its recent entry into Egypt as given by Ballou[5] and others is circumstantial and practically determined, both as to time and place of introduction. Briefly, there were large importations of imperfectly ginned or of seed cotton from India in the years 1906 and 1907. Much of this cotton was distributed to towns near Alexandria for ginning. The discovery of the pink bollworm in the Delta region in Egypt was in the lower Delta, in the vicinity of towns where this seed cotton went for ginning. It was first noted in 1911 at Foueh, and in the following year at four other points, three of which were very close to Foueh. The first substantial general field injury observed from this insect was in 1912 near Alexandria. By the end of that year, 1912, however, the insect was found pretty well throughout the Delta and also north of Cairo to a distance of a hundred miles or more, but in no case except the one field referred to was it abundant enough to do any material injury. The increase of the damage in Egypt by this insect from that period has been steady in spite of the enforcement of the most strenuous field and other control operations.

The possibility of the importation of this insect from India with a large quantity of cotton seed imported into Egypt in 1906–7 is perfectly patent in view of the known occurrence of this insect in India for three quarters of a century.

From the evidence, herein reviewed, it would seem to be well established that the native home of the insect included India and perhaps other countries of southern Asia. If its natural range extended to Africa it must

[4] Fletcher, T. Bainbrigge, Rep. Proc. Sec. Ent. Meeting. Pusa., February, 1917, pp. 10, 111–14, 1917.

[5] Ballou, H. A., *Jour. Econ. Ent.*, Vol. XI., pp. 236–45, 1918.

have been limited to equatorial Africa and certainly it had not reached prior to 1906 or 1907 the cultivated district of the Nile Valley where cotton has been a commercial crop of importance for at least a hundred years. This point of view is now held by the experts who have studied this insect in Africa and India such as Willcocks, Fletcher and Ballou.

C. L. Marlatt

HARRY KIRKE WOLFE

Professor Harry Kirke Wolfe, head of the department of philosophy in the University of Nebraska, died suddenly on July 30 last at Wheatland, Wyoming, whither he had gone for a brief outing. Dr. Wolfe was born in Illinois, in 1858, but he was a Nebraskan by rearing and he received his collegiate education in the state university. In 1883 he went to Berlin to carry further the study of the classics, which was then his interest, but while in Germany he was won to psychology, and changing to Leipzig became one of the group of young Americans who had been attracted by the fame of Wilhelm Wundt, and who were to revolutionize the teaching of the science upon their return to America. Dr. Wolfe was in the vanguard of this movement. He received his doctorate in 1886, and in 1889 he was made professor of philosophy in his alma mater, where previously this field had been the prerogative of the college head. Immediately he began to build up the physiological and psychophysical foundations of his subject, creating the first laboratories in psychology open to undergraduates in the country—a feature of the instruction which to the end was distinctive of his work. From 1889 to 1897 Dr. Wolfe's work was attended with a truly phenomenal success, not only in the immediate strength of his department but also in its influence, for he started not a few young men toward the advanced cultivation of his science—among them Professors Pillsbury of Michigan and Bentley of Illinois—as well as of the broader field of philosophy. It was in this period, too, that he published a number of monographic articles in psychophysics (out of a great series planned), and he was connected with the appearance of the *American Journal of Psychology*. Unhappily the career thus splendidly begun was interrupted by one of those accesses of bigotry which sometimes seize college authorities; and under absurd political and religious charges he was asked to resign in 1897. In the period from 1897 until 1905 Dr. Wolfe was engaged in public school work, with the result that his interest in secondary education became the predominant one for the remainder of his life. In 1905 he was called to the University of Montana, and two years later back to the University of Nebraska, where again he became head of the department which years before he had founded. This position he held until his death. In this latter period, while his old interest in experimental psychology was as keen as ever, it had constantly the bias of the secondary school needs in mind, and his laboratories became the training grounds for scores of young men and women who were to enter the public school field. Certainly there are few, if any, teachers in the middle west who have so profoundly and beneficially influenced the later development of its secondary education.

Such in brief is the outward career of a man whom all who knew him knew to be possessed of a genius for teaching. There are few qualities which the teacher should possess which he did not own in exalted measure: keenness and kindness, unfailing humor and patience and generosity of soul, and the power to inspire, all these were his; and he was loved by those under his influence as few men are loved. It is an irony—perhaps attaching to his quiet yet steadfast personality, for he was above all a man of principle—that such a man should twice in his career have come under the charges of malicious ignorance. The first occasion was in 1897. Ten years later, when he was returned to his old position his vindication came (as it was bound to come), though meantime the character of his life work had been once for all altered. The second occasion was in June of 1918, when through idle gossip his name was dragged before the inquest into loyalty forced upon the university by the State Council of Defense. He was, of

course, immediately vindicated; but the cruel fact of the charge was a hurt which—humorously as he passed it off—made the more precarious the heart trouble from which he suffered, and led quickly to the end. Dr. Wolfe was one of the few men to whom, in action and motive and principle, the word "noble" can be clearly applied. He was a lover of truth and righteousness, of his country and of humanity, and of the best in all things—worthy of the name of philosopher.

HARTLEY B. ALEXANDER
UNIVERSITY OF NEBRASKA,
September, 1918

SCIENTIFIC EVENTS

THE DEVELOPMENT OF THE DYESTUFFS INDUSTRY

THE success of the American chemists and chemical manufacturers in developing the dyestuffs industry, when the supplies of dyes from Germany were cut off, is shown in a report issued by the United States Tariff Commission, entitled "Census of Dyes and Coal-tar Chemicals, 1917."

At the outbreak of the European war, Germany dominated the world's trade in dyes and drugs derived from coal tar. Before the war, seven American firms manufactured dyes from imported German materials. In 1917, 190 American concerns were engaged in the manufacture of dyes, drugs and other chemicals derived from coal tar, and of this number 81 firms produced coal-tar dyes from American materials which were approximately equivalent in total weight to the annual imports before the war. The total output of the 190 firms, exclusive of those engaged in the manufacture of explosives and synthetic resins, was over 54,000,000 pounds with a value of about $69,000,000.

Large amounts of the staple dyes for which there is a great demand are now being manufactured in the United States. A few of the important dyes, such as the vat dyes derived from alizarin, anthracene and carbazol, are still not made. The needs of the wool industry are being more satisfactorily met than the needs of the cotton industry.

The report gives in detail the names of the manufacturers of each dye or other product and the quantity and value of each product, except in cases where the number of producers is so small that the operations of individual firms would be disclosed. Seventeen hundred and thirty-three chemists or engineers were engaged in research and chemical control of this new industry, or 8.8 per cent. of the total of 19,643 employees. The report also contains an interesting account of the history and development of the industry since the outbreak of the European war.

On August 27, Dr. H. O. Forster, a member and director of the Technical Committee of British Dyes, Limited, lectured on August 27 on "The decay and renaissance of British dye making" at the British Scientific Products Exhibition, King's College. He stated that in 1878 the color industry in Germany was four times as valuable as that of England. Of £3,150,000 worth of coal tar colors produced in the world Germany produced £2,000,000, four fifths of which was exported, while Switzerland produced £350,000, and England only £450,000 worth.

That was forty years ago; confronted by these figures, people would hesitate to believe those who said that in two or three years England should be able to do all that Germany could in regard to the dye industry. It would take ten or fifteen years of unremitting labor and extraordinary patience and liberal expenditure on chemistry before we could hope to achieve the position which Germany had reached before the war in this industry. He said in conclusion:

> They have three times as many chemists as we have, and their population is half as large again. We shall have to make a great effort if we are going to reach them. The industry is not an El Dorado in which one has to dig once in order to make countless thousands. It can only be achieved if money is spent on experiment. That was how Germany got on, and unless we tread the thorny path the Germans have followed, there is not the slightest hope of our catching them up in this industry. They will keep it for all time.

On the conditions of success in England Sir Henry Armstrong writes to the London *Times:*

The action taken by a large majority of the shareholders of British Dyes (Limited) at Huddersfield practically involves determining the existence of the government company as a separate business and placing the technical management in the hands of Dr. Levinstein.

Not a moment should be lost in the necessary reconstruction. Mr. Norton stated at the meeting that it was proposed "there should be three directors appointed by the shareholders of each company and three by the government, so that it would always be possible for the state to stop any abuse." The number is too large, and to give the government control of a scientific enterprise is simply to ask for disaster—the four years of failure of the company under such control should at least have taught us this much.

In the next place, it must be recognized that science must be of and at the works. All laboratory operations should at once be transferred to the factory. One of the main functions of the research department in German works—that to which more than to any other they owe their peculiar efficiency—has been that of a training school for the works. One of the chief reasons of the government company's lack of success has been the absence of sympathy between the works and those who were carrying on scientific inquiry for the company outside the works, as well as the failure to develop an efficient works staff. There has been much loose talk during the past four years with regard to cooperation between the university and industry; the real function of the university must be to serve as the training ground for industrial workers, and the sooner the professoriate learn to apply themselves wholly and solely to this form of industry the greater will be our progress as a country.

Thus far, in their attempt to nurse the dye-stuff industry into existence, government has made use of entirely unskilled agents—and, as was to be expected, the failure has been complete. If any further effort is to be made by the state, let it be a rational one. Unless and until the Board of Trade and the so-called Controller of Dyestuffs be aided by a scientific advisory board, injury rather than advantage must result from further state interference.

HEALTH MISSION TO ITALY UNDER RED CROSS AUSPICES

The War Council of the American Red Cross has announced the personnel of the medical unit to conduct a health campaign in Italy with the stamping out of tuberculosis as its particular objective. The Italian tuberculosis unit of the American Red Cross, as the organization will be known, will be under the supervision of Colonel Robert Perkins, Red Cross commissioner for Italy.

Included in the personnel of the unit, which numbers 60 persons, are many of this country's best known tubercular specialists, as well as physicians who have been successful in the lines of work which they will be called upon to perform. The director of the unit is Dr. William Charles White, of Pittsburgh. Others are: Dr. John H. Lowman, professor of clinical medicine at Western Reserve University, Cleveland, chief of the medical division; Dr. Louis I. Dublin, of New York, statistician of the Metropolitan Life Insurance Co., chief of the division of medical statistics; Dr. Richard A. Bolt, of Cleveland, connected with the health department of that city, chief of child-welfare division; Dr. E. A. Paterson, of Cleveland, chief of division of medical inspection of public schools; Dr. Robert G. Paterson, of Columbus, Ohio, head of the tuberculosis branch of the state health department, chief of the division of education and organization; Miss Mary S. Gardner, head of the bureau of public-health nursing of the American Red Cross, chief of division of public-health nursing. The executive manager of the organization is Lewis D. Bement, of Framingham, Mass.

Dr. White, who was director of the Red Cross tuberculosis unit in France for ten months, made the following statement concerning the situation in Italy:

> It must not be thought that the United States is sending this delegation because Italy is backward in this respect. As examples of Italian work one may cite the situation in the city of Genoa, which for many years, probably over twenty, has had a museum showing the various phases of tubercular diseases, as well as modern methods of combating them. Campaign and educational literature are there for distribution among the people. Attached to the museum are a dispensary and visiting nurses' school not surpassed in any of the American cities.
>
> In Genoa also is an attractive open-air school.

In the middle of the enormous sea wall, of primitive structure, with the surf washing against the wall below it and protected from the winds of the north by the wall itself, in constant sunshine, provision is made for 200 or 300 Genoese children of the more unfortunate classes. They arrive in the morning, get their midday meal and morning luncheon, and are sent to their homes in the evening. Play is supervised by special teachers, bathing facilities arranged for; the children take singing lessons and a healthier, happier looking lot of children one could scarcely find.

When we visited them in February they sang the Italian national anthem and "The Star Spangled Banner" with vigor and enthusiasm. There are also children's hospitals in the mountains. In Rome the *Giornale d'Italia* raised money by popular subscription and built a beautiful hospital on one of the hills for children with bone tuberculosis.

The American Red Cross had the privilege of giving $25,000 to this hospital. These are just a few conspicuous instances of what the Italians have already done for the study and cure of tuberculosis.

But Italy's great spirit for progression was arrested with the declaration of war, which compelled the mobilization of all her resources for the one big task in hand. It naturally followed that the civilian population had to wait until the military needs were cared for.

Then, as in France, this emergency was created. Conditions were growing harder to grapple with each day. When Italy saw the help we were extending to France she invited the United States to come to her shores with such assistance as we could offer.

CIVIL SERVICE EXAMINATIONS

THE United States Civil Service Commission announces open competitive examinations as follows:

List No. 1. Examinations of the nonassembled type; that is, those in which competitors are not assembled for scholastic tests, but are rated upon the subjects of education, training and experience, and corroborative evidence. Applications for these examinations are received at any time: Inspector of mechanical or electrical equipment, inspector of structural steel, supervising or traveling accountant, construction cost accounting supervisor, automotive engineer, automotive designer, automotive draftsman, automotive tracer, mechanical draftsman, War Department; special field agent in entomology, Department of Agriculture; tabulating mechanician, Census Bureau; elevator conductor, departmental service.

List No. 2. Examinations of the nonassembled type, for which applications must be filed by the dates specified: Horticulturist, Department of Agriculture, September 17; architectural designer, architectural draftsman, Panama Canal Service, September 17; photographer, War Department, September 24; mechanical draftsman, Patent Office, September 24; assistant in dairy cattle breeding, assistant in fish investigations, assistant superintendent of seed warehouse, Department of Agriculture, September 24; sugar chemist and technologist, Bureau of Standards, September 24; assistant clinical psychiatrist and psychotherapist, St. Elizabeths Hospital, September 24; chemical laboratorian, chemist's aid, various branches, September 24.

List No. 3. Examinations in which competitors will be assembled for scholastic tests: Laboratory aid in agricultural technology, Department of Agriculture, October 2; business principal, Indian Service, October 2–3; inspector of safety appliances. inspector of hours of service, Interstate Commerce Commission, October 2–3.

Full information and application blanks may be obtained by addressing the United States Civil Service commission at Washington, D. C., or the civil-service district secretary at Boston, New York, Philadelphia, Atlanta, Cincinnati, Chicago, St. Paul, St. Louis, New Orleans, Seattle, or San Francisco.

SCIENTIFIC NOTES AND NEWS

MAJOR GENERAL WILLIAM C. GORGAS, Surgeon-General, U. S. A., accompanied Secretary Baker on his recent visit to France.

COLONEL JOHN M. T. FINNEY, Baltimore, who returned to this country early in August on a special mission, has again sailed for France to assume his duties as chief consultant surgeon of the American Expeditionary Forces.

Dr. H. S. Washington, of the Geophysical Laboratory of the Carnegie Institution, has been appointed chemical associate to the scientific attachés at the American embassies in Paris and Rome.

Professor Graham Lusk, of Cornell Medical College, and one of the representatives at the recent meetings of the "Interallied Scientific Food Commission" abroad, will give at the New York Academy of Medicine on Thursday evening, October 3, at nine o'clock, the Wesley M. Carpenter lecture on "The scientific aspect of the interallied food situation."

Dr. William P. Harlow, head of the school of medicine of the University of Colorado, has been appointed a major in the Medical Corps, and has been placed in charge of General Hospital No. 21.

Dr. H. L. Hollingworth, associate professor of psychology in Barnard College, Columbia University, has been commissioned a captain in the Sanitary Corps, and will report at the Plattsburg Barracks.

Rhys D. Evans, associate professor of physics in Bowdoin College, formerly instructor in physics, Ohio University, Athens, Ohio, the son of Professor D. J. Evans, of the latter institution, has been commissioned captain in the Chemical Warfare Service.

Dr. W. E. Carroll, professor of animal husbandry at the Utah Agricultural College, has been commissioned as captain in the Sanitary Corps of the United States Army, and will report to Fort Oglethorpe, Georgia, for special training at the medical officers' training camp.

Dr. W. L. Argo, formerly of the University of California, has been commissioned a lieutenant in the Chemical Warfare Service and has been sent to France.

Dr. W. J. Robbins, formerly professor of botany at the Alabama Polytechnic Institute, has been appointed a lieutenant, Sanitary Corps, and is stationed at Yale University.

John Paul Givler, of the department of zoology, University of Tennessee, has been appointed first lieutenant in the Sanitary Corps.

Dr. Frank C. Gates, professor of biology at Carthage College, Carthage, Ill., has been commissioned second lieutenant in the Sanitary Corps and reported at Yale University on September 9.

Lieutenant Charles A. Waters, who recently returned to this country after fourteen months' service with the Johns Hopkins Base Hospital in France, will leave shortly for Fort Oglethorpe, Ga., where he will be an instructor in the roentgen-ray division of that cantonment. He expects to return to France later.

O. L. Thomas has been transferred from the Experimental Station of E. I. du Pont de Nemours and Co., Wilmington, Del., where he acted as research chemist, to the U. S. Government Powder Plant at Jacksonville, Tenn., where he will be chief supervisor of caustic soda manufacture and soda ash recovery.

The Mary Kingsley medal of the Liverpool School of Tropical Medicine for research in tropical diseases has been awarded to Dr. Griffith Evans, the discoverer of the trypanosome of Surra, a disease of horses and camels of India, Burma, and the east.

Dr. Caroline S. Finley, Dr. Anna I. Von Sholly and Dr. Mary Lee Edward, of New York, who are connected with the Women's Overseas Hospitals, have been decorated by the French government and commissioned lieutenants in the Medical Corps of the French Army, the commissions having been bestowed for excellent surgical work and treatment of the wounded under heavy bombardment in a hospital at the French front.

R. G. Webber, assistant professor of physics, Ohio University, Athens, Ohio, who has been in the service of the government during the summer at the Watertown Arsenal, has had his leave of absence extended through the coming college year to continue his work in the physical testing department of the arsenal.

Professor C. H. Gordon, Ph.D., professor of geology and mineralogy, University of Tennessee, has returned after an absence of two weeks in lecturing at army camps under the auspices of the Army Y. M. C. A. The

first week was spent at Camp Hancock, Augusta, Ga., and the second at Camp Sevier, Greenville, S. C. The plan of giving lectures in the camps on geographical and travel subjects was undertaken at the instance of the committee on geology and geography of the National Research Council, of which Professor W. M. Davis, of Harvard University, is chairman.

DR. D. S. JENINGS has been appointed to the staff of the Experiment Station of the Utah Agricultural College as expert in charge of an extensive soil survey to be made of the state of Utah. This survey will be conducted in consultation with the station departments of agronomy, geology, horticulture, irrigation and drainage, botany, chemistry and bacteriology, and farm management.

PROFESSOR A. S. HITCHCOCK, Bureau of Plant Industry, spent the month of August studying and collecting grasses in Arkansas, Oklahoma, Texas and Colorado.

DR. IRA E. LEE, instructor of chemistry at the University of Rochester, has become a research chemist with E. I. du Pont de Nemours & Co., Wilmington, Del.

DR. ALFRED R. SCHULTZ has presented his resignation from the U. S. Geological Survey, to become manager of a hydro-electric power and milling company.

MR. JOHN A. COYE has resigned his position as chief chemist with the Engineering Experiment Station of the Iowa State College, Ames, Iowa, to accept the position of assistant chemist with the General Chemical Company at their Laurel Hill Works.

PROFESSOR JOJI SAKURAI, who has arrived in London from Japan, has brought with him a contribution from Japan to the Ramsay Memorial Fund, amounting to £487 9s. 2d., which he has handed over to the honorable treasurers, Lord Glenconner and Professor Collie.

UNIVERSITY AND EDUCATIONAL NEWS

THE movement for reform in the management of the universities in Argentina for which the professors and students of the universities have been keeping up an agitation, has culminated in a bill presented by the president of the republic to congress for deliberation and action. The bill coincides in general with the demands of those contending for reforms. It provides that the dean shall be elected by the professors, he shall serve four years and can not succeed himself. The election will be by a council of seven members, one representing the students, one the alumni and the others the professors.

AT Harvard University, Dr. Wallace Clement Sabine has been appointed acting director of the Jefferson Physical Laboratory, and Dr. Herbert Sidney Langfield, acting director of the Psychological Laboratory.

PROFESSOR LOUIS DE L. HARWOOD, Montreal, has been appointed dean of the medical department of Laval University.

F. C. WERKENTHIN, assistant professor of biology in New Mexico College of Agriculture and Mechanic Arts, has been elected to the associate professorship of botany in New Hampshire Agricultural College and will assume his new duties with the opening of college in September.

AT Cornell University Dr. R. C. Gibbs has been promoted to be professor of physics; Dr. H. E. Howe, formerly professor of physics at Randolph-Macon College, has been appointed assistant professor.

DR. H. L. WALSTER, of the college of agriculture of the University of Wisconsin, Madison, Wisconsin, has returned to his position as associate professor of soils in the university after having spent a year's leave of absence at the University of Chicago, where he received the Ph.D. degree in plant physiology and plant ecology.

THE following changes in the faculty of the department of agriculture in the University of Minnesota have been made recently: H. H. Kildee has resigned as chief of the dairy husbandry division in order to take charge of animal husbandry work at Iowa State College,

and has been succeeded by C. H. Eckles, formerly of the University of Missouri; J. S. Montgomery and T. G. Paterson have resigned as associate professors of animal husbandry, and R. C. Ashby as assistant professor of animal husbandry, to enter commercial work; W. H. Peters, formerly head of animal husbandry of the North Dakota Experiment Station, has been appointed professor of animal husbandry; P. A. Anderson has been promoted from instructor to assistant professor of animal husbandry; J. C. Cort, formerly of Iowa State College, has been appointed assistant professor of dairying.

DISCUSSION AND CORRESPONDENCE

RED RAYS AND PHOTOELECTRIC EFFECT

I WISH to call attention to an error which should be corrected as it is being repeated and found its way into such standard texts as Hughe's "Photoelectricity" (Cambridge University Press). Red light does *not* give a photoelectric effect with phosphorescent calcium sulphide, as the effect stops at the wave-length of about 4,200 Ångström, as was shown by the writer.[1] This result was later confirmed at the University of Berlin. The result is of considerable theoretical importance because the theory of the photoelectric effect which takes into account the necessity of a critical energy content before the electrons can be shot off, shows that there will be a wave-length for each element beyond which no photoelectric effect will be produced. The element which gives the photoelectric effect in phosphorescent calcium sulphide is not known, but has been supposed by the writer to be sulphur as it is photoelectric for ultra-violet light and it was shown experimentally to give a photoelectric effect for wave-lengths *longer* than 3,200 Ångström. This hypothesis could be established by showing that the photoelectric effect of sulphur ended at the same point as was shown for phosphorescent calcium sulphide.

When the writer began an investigation of the photoelectric effect of phosphorescent material in 1910 at Yale University, it was *supposed* that the result obtained in 1909 by Lenard and Saeland at the University of Heidelberg was correct. However, it was found that the photoelectric effect of phosphorescent calcium stopped at about 4,200 Ång., which is a shorter wave-length than red light. Thus the result of Lenard and Saeland is incorrect.

The error arose from confusing the effect of red light on the conductivity, which did exist, with that of the photoelectric effect which did not exist. In their paper in the *Annalen der Physik,* Lenard and Saeland described what they thought to be a new effect with red light which was called "Aktinodielektrische Wirkung." This effect differed from the photoelectric effect in that the test plate instead of charging up only positively, charged up both positively and negatively. It was thought that the long heat or red waves being more nearly comparable with the dimensions of the molecules affected them beyond the point where the photoelectric effect stopped. However, after working about a year on the effect of red rays on phosphorescent calcium sulphide, the writer came to the conclusion that no photoelectric effect could be obtained with red light and that the actinodielectric effect was nothing more than an increase in conductivity such as had previously been known to exist for selenium.

After the foregoing conclusion was reached a reexamination of the original article of Lenard and Saeland showed that on account of a faulty construction of their apparatus the plate on which the material was placed was not completely insulated from the accelerating and retarding fields, as is necessary when the photoelectric effect only is to be obtained.

In order to confirm the conclusion, my own apparatus was later reconstructed at the Massachusetts Agricultural College so as to obtain both effects separately at will. It was shown with this apparatus that sulphur was both photoelectric and actinodielectric. The photoelectric effect required a high vacuum, but the actinodielectric effect worked in addition at atmospheric pressure, the direction of the current depending upon the direction of the applied field.

[1] "The Photoelectric Effect of Phosphorescent Material," *American Journal of Science,* 1912.

The conductivity of phosphorescent calcium sulphide was later separately investigated at the University of Heidelberg, and it was shown that certain wave-lengths not in the infra-red gave a maximum effect, which was contrary to what one might have expected from Lenard's theory. Rather the effect was a maximum near the point where the photoelectric effect stopped, suggesting some relation between the photoelectric and actinodielectric effect. An investigation of the relation between these two effects (which amounts to finding out the relation between the ease with which the electrons are ejected and the increase in conductivity for different wave-lengths of light) was started for sulphur, during the summer of 1913, by the writer at the Davy-Faraday Research Laboratory of the Royal Institution, London, England, but was not finished.

The relation between the photoelectric effect, actinodielectric effect and phosphorescence has been discussed by the writer and a general theory of phosphorescence has been developed which includes fluorescence, fluorescent X-rays, organic phosphorescence and self-luminous radioactive substances.[2] In the review of this theory in the "Beiblatter zu den Annalen der Physik" the difference between Lenard's theory of phosphorescence and the author's is not clearly pointed out. The author's theory takes into account resonance, Stokes's law and a critical energy content, which is not done by Lenard.

In conclusion, in respect to phosphorescent calcium sulphide, it should be said that red light does increase its conductivity, but *does not* give a photoelectric effect.

CHESTER ARTHUR BUTMAN

SPECIAL GROWTH-PROMOTING SUBSTANCES AND CORRELATION

THE vigor of potato sprouts bears a direct relation to the size of the seed piece, or in other words to the amount of tissue surrounding the eye. When a certain minimum is reached, the vigor of the sprouts decreases as the size of the seed piece is reduced. The weak, slender sprouts produce correspondingly weak plants which remain weak during their entire period of growth and yield a small crop of tubers.

The weak sprouts are not due to lack of usual food materials, as sprouts on pieces still large enough to contain an abundance of these substances, show considerable decrease in vigor. If a lack of sufficient ash constituents is responsible for the weak sprouts, they might be expected to approach their usual vigor if the small pieces be allowed to sprout in rich soil, as the sprouts form roots very quickly in moist soil. The sprouts from such pieces, however, do not gain any vigor under these conditions.

It seems logical to conclude that the potato tuber contains a limited amount of a special growth-promoting substance and if the amount of tissue surrounding the growing bud is too small, there is not enough of this substance available for normal growth.

Some of the experimental data is included in Bulletin No. 212 of the Maryland Agricultural Experiment Station under the following title: "Physiological Basis for the Preparation of Potatoes for Seed." While this bulletin was in press an article appeared by Loeb, in which he states that equal masses of sister leaves of *Bryophyllum calycium* produce approximately equal masses of shoots in equal time and under equal conditions, even if the number of the shoots varies considerably. He concludes that the limited amount of material available for growth and the automatic attraction of the material by the buds which grow out first, explain the inhibiting effect of these buds on the growth of the other buds.

If the correlative inhibition of bud growth on the potato tuber has a chemical basis it does not appear to be identical with the growth-promoting substance which the writer has postulated and which seem to effect the growth of sprouts only after they have started. Several facts in connection with the growth of sprouts on potato tubers could be mentioned to substantiate this conclusion but the two following experiments seem sufficient.

If a potato tuber bearing vigorous sprouts on the terminal end is cut transversely into

[2] See "The Electron Theory of Phosphorescence," *Physical Review*, 1912.

halves, sprouts will appear on the basal half. Therefore, this half still contained sufficient growth material to produce sprouts. This proves that, although the basal buds would not grow out before their connection with the terminal end of the tuber was severed, they were not prevented from doing so because the terminal sprouts had automatically attracted the limited amount of material for growth.

If a tuber, before the end of the rest period, is cut into transverse slices the buds on the basal slices will grow out first. If the tuber is cut lengthwise into fractions the growth of basal buds is entirely suppressed. The terminal buds on these fractions do not produce sprouts until the end of the natural rest period for whole tubers, which in some cases is a month after the basal buds on the transverse slices have grown out. The basal buds seem to have a shorter rest period than the terminal ones but are unable to grow out until their connection with the terminal end of the tuber is severed. This experiment shows that the terminal end of the tuber, even before its buds have grown out, may inhibit the growth of buds more basally situated.

Potatoes are sometimes affected with a physiological disease called "Spindling Sprout," because the whole tubers produce long, slender, weak sprouts. In all probability the special growth-promoting substances are abnormally low in these tubers. In this connection, however, the most interesting symptom of the disease is a lack of any inhibiting effect of the terminal buds on the other buds, as the sprouts appear, as a rule, simultaneously over the entire tuber. The behavior of the *Bryophyllum* plants reported on by Braum[1] may have been due to a condition of the particular plants analogous to the "Spindling Sprout" of the potato. If this were true it would account for the instances of regeneration of *Bryophyllum* leaves seemingly at variance with the experiments described by Loeb.[2]

Charles O. Appleman

Maryland Agricultural Experiment Sta., College Park

[1] Braun, Lucy E., *Bot. Gaz.*, 65, 191–193, 1918.
[2] Loeb, J., *Bot. Gaz.*, 65, 150–174, 1918.

QUOTATIONS

THE MEDICAL PROFESSION IN GREAT BRITAIN AND THE WAR

The effect of the war upon the number of medical students in their different years of professional study has been described from time to time by the president of the General Medical Council. Between the years 1910 and 1914 the annual entry of first-year medical students averaged roughly 1,440. Since the war the number of these entries has increased by five or six hundred a year. Thus the whole number of students actually pursuing medical studies in the medical schools of the United Kingdom has shown a steady upward movement. In May, 1916, the total was 6,103, in January, 1917, it was 6,682, in October, 1917, it was 7,048, while the latest figure, for May, 1918, was 7,630. But for some time the larger withdrawals of male students from the medical schools for combatant service or for service as surgeon probationers in the navy, more than nullified the increased entries and bade fair to produce a serious deficiency of new practitioners in the years 1918 and 1919. Urgent representations upon this matter were made to the government. As a result something has been done to make good the threatened shortage by the return of third-year students from active service to complete their studies, by the retention in the medical schools of students on their way towards qualification who are liable to be called to the colors, and by limiting the period of service of surgeon probationers. The Minister of National Service has further undertaken to provide that, if possible, the supply of students in training shall be kept at a level sufficient to give an annual yield of at least 1,000 new practitioners. This is the official estimate, but it will be well to remember that though there has been heavy wastage among medical men through the hazards and hardships of war the declaration of peace will be followed by the release from military duty of the majority of the medical men now serving in the army and navy. Demobilization is a matter which effects the medical profession at least as much as other sections of the community. The method in

which the demobilization of medical men may best be carried out is being carefully studied by the British Medical Association. They will no doubt be released gradually as the other branches of the army are demobilized, but many will be eager to return to civil life, and in any estimate of the numbers of the medical profession in this generation regard must be had to the fact that during the last three years practically all newly qualified practitioners have been taken into the army. Within some not very long time after the conclusion of war many of them will be liberated to return to civil life, and will naturally and properly have the first claim upon the public and upon pubic authorities.

Another feature of the last four years has been the great increase in the number of women going in for the study of medicine. In May last there were 2,250 women medical students in the United Kingdom—a figure 23 per cent. greater than the total for January, 1917, and several times larger than in 1914. For this remarkable growth the war must be held mainly responsible. As for the professional instruction of these large numbers of students, men and women alike, there can be no doubt that the war by diverting the activities of many of their teachers into other channels or other spheres has considerably depleted the staffs of the medical schools as well as of other educational institutions in which the preliminary subjects and various branches of medical science are taught. Nevertheless, the teachers who continue at their posts are making every effort to maintain the standard of instruction, in spite of war-time difficulties.

What will be the prospects of the medical profession when the war is over? The medical services have acquitted themselves extremely well in the war, and medical science will come out of it with an enhanced reputation. Military medicine and surgery have advanced, and not a few of the results of practise and research in the war zones will remain as permanent additions to knowledge. The treatment of wounds has steadily improved, orthopedic treatment for the crippled and maimed is more successful than ever; preventive medicine in camp and trenches has scored great triumphs; the work of the pathological laboratory and of the bacteriologist has proved to be of the utmost value. In civil life the spirit of the times is all in favor of extension and coordination of the public health services. This is reflected in the widely-supported proposal for the setting up of a Ministry of Health, which has received fresh impetus during the past few months. The Minister of Reconstruction, according to rumor, has had a draft bill in his pocket since the beginning of the year, but it does not appear to have won the approval of the Committee of the Cabinet on Home Affairs. The possibilities of the future are large, but as yet ill defined. More medical care has been provided for expectant mothers, for infants, for children, and for the victims of venereal diseases; a great increase in the public work of pathological laboratories all over the kingdom may be confidently expected. All this means an increase in the official medical services. What ultimate fate is in store for the private practitioner we will not venture to foretell. Before the war, as we have pointed out above, his position had been profoundly affected by the Insurance scheme which converted the majority of general practitioners into part-time civil servants and subjected them to the discipline of Insurance Commissioners. Pecuniarily it has benefited some and impoverished others. One thing at least can be said: the immediate future is full of uncertainty, especially for the general practitioner. Forces which had long been at work beneath the surface have gained strength through the circumstances of war and many believe that the state will gradually tighten its grip on the medical profession.

Every doctor should possess a strong sense of *esprit de corps*. Medicine is a profession which, when it comes to business dealings of any sort, the general public—as also public authorities—persistently regard as being of a semi-philanthropic character. Furthermore, it is a profession whose aims and requirements are very ill understood by persons who have not undergone a medical education. Hence the interests of the medical profession, both on its financial and scientific sides, are continu-

ally being attacked, sometimes openly, sometimes insidiously. It is all-important, therefore, that medical men and women should band themselves together for the common protection of themselves and the profession to which they belong, and to this end join the British Medical Association. For the objects of this body are to promote the progress of medical science and the interests of the medical profession, and its past history shows that it has well fulfilled them.—*The British Medical Journal.*

SCIENTIFIC BOOKS

The Wings of Insects. By J. H. Comstock. Ithaca, N. Y., The Comstock Publication Company. Pp. xviii + 423, 9 plates and 427 figs.

In these days of distraction from pure science it is a pleasure to note the appearance of Professor Comstock's book on the wings of insects. The whole book is devoted to an exposition of the uniform terminology of the wing veins of insects, a field of scientific research in which Professor Comstock has long been preeminent. The book is founded upon the now well-known theory that the wing veins of insects can only be homologized by a study of the tracheæ which precede them. The historical phases of this theory are discussed together with the general features and development of the wings of insects. A general chapter that ought to be appreciated is the one on paleontological data. Professor Comstock's conclusion after reviewing the various fossil forms is: "A study of the paleontological data confirms to a remarkable degree the conclusions drawn from the study of the ontogeny of living insects as to the probable primitive type of wing venation."

Following the general chapters are special chapters devoted to the wings of the various orders of insects. In these chapters the author has not only used the results of his original investigations but has also used the results of various workers who have given special attention to the different groups. These two sources of information have been welded into a concrete whole that taken together with the illustrations both of wing tracheation and venation can not help but convince entomologists not only of the desirability of a uniform terminology but also of the firmness of the foundation upon which the Comstock system is based.

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THE PROCEEDINGS OF THE NATIONAL ACADEMY OF SCIENCES

The fourth number of Volume of the *Proceedings of the National Academy of Sciences* contains the following articles:

Dynamical aspects of photosynthesis: W. J. V. Osterhout and A. R. C. Haas, Laboratory of Plant Physiology, Harvard University. *Ulva,* which has been kept in the dark begins photosynthesis as soon as it is exposed to sunlight. The rate of photosynthesis steadily increases until a constant speed is attained. This may be explained by assuming that sunlight decomposes a substance whose products catalyze photosynthesis or enter directly into the reaction. Quantitative theories are developed to account for the facts.

Mobilities of ions in air, hydrogen and nitrogen: Kia-Lok Yen, Ryerson Physical Laboratory, University of Chicago. Extensive experiments, the rusults of which are in perfect accord with the "small-ion" hypothesis, as contrasted with the "cluster" hypothesis.

Thermo-electric action with dual conduction of electricity: Edwin H. Hall, Jefferson Physical Laboratory, Harvard University. A continuation of previous papers. The hypothesis of progressive motion by the "free" electrons only has been extended to the case of dual electric conduction.

Terrestrial temperature and atmospheric absorption: C. G. Abbot, Astrophysical Observatory, Smithsonian Institution. The earth's surface sends out 0.50 calorie per cm^2 per minute on the average, and of this only a small part escapes to space. Hence, the atmosphere is the main radiating source, furnishing three fourths of the output of radiation of the earth as a planet.

Mobilities of ions in vapors: KIA-LOK YEN, Ryerson Physical Laboratory, University of Chicago. A continuation of the study of the vapors SO_2, C_2H_6O, C_2H_4O, C_5H_{12}, etc., with the conclusion that the small ion theory is further corroborated.

A contribution to the petrography of the South Sea Islands: J. P. IDDINGS and E. W. MORLEY, Brinklow, Md., and West Hartford, Conn. Thirty detailed chemical analyses of lava from the South Pacific Islands are given, with a discussion of the results.

The law controlling the quantity and rate of regeneration: JACQUES LOEB, Rockefeller Institute for Medical Research, New York. The quantity of regeneration in an isolated piece of an organism is under equal conditions determined by the mass of material necessary for growth circulating in the sap (or blood) of the piece. The mystifying phenomenon of an isolated piece restoring its lost organs thus turns out to be the result of two plain chemical factors, the law of mass action and the production and giving off of inhibitory substances in the growing regions of the organism.

National Research Council: Minutes of the first meeting of the Executive Board of War Organization; Research Information Committee.

THE fifth number of Volume 4 contains the following articles:

Some spectral characteristics of cepheid variables: W. S. ADAMS and A. H. JOY, Mt. Wilson Solar Observatory, Carnegie Institute of Washington. The hydrogen lines are abnormally strong in Cepheid spectra, which are classified first on a basis of the hydrogen lines, and, second, on the more general features of the spectra.

Types of achromatic fringes: CARL BARUS, Department of Physics, Brown University.

Interference of pencils which constitute the remote divergences from a slit: CARL BARUS, Department of Physics, Brown University.

A study of the motions of forty-eight double stars: ERIC DOOLITTLE, Flower Observatory, University of Pennsylvania. A classification of the stars is set up for the purpose of determining those pairs upon which observations are most urgently needed.

The structure of an electromagnetic field: H. BATEMAN, Throop College of Technology, Pasadena. All electrical charges are supposed to travel along rectilinear paths with the velocity of light. When electricity appears to move with a smaller velocity, it is made up of different entities at different times.

Invariants which are functions of parameters of the transformation: OLIVER E. GLENN, Department of Mathematics, University of Pennsylvania. A general discussion of a systematic theory and interpretation of invariantive functions which contain the parameters of the linear transformations which leaves invariant a binary quadratic form, including the invariants of relativity.

THE sixth number of Volume 4 contains the following articles:

Effects of a prolonged reduction in diet on twenty-five men: I. Influence on basal metabolism and nitrogen excretion: FRANCIS G. BENEDICT and PAUL ROTH, Nutrition Laboratory, Carnegie Institution of Washington, Boston. *II., Bearing on neuro-muscular processes and mental condition:* WALTER R. MILES, Nutrition Laboratory, Carnegie Institution of Washington, Boston. *III., Influence on efficiency during muscular work:* H. MONMOUTH SMITH, Nutrition Laboratory, Carnegie Institution of Washington, Boston.

Possible action of the sex-determining mechanism: C. E. MCCLUNG, Zoological Laboratories, University of Pennsylvania.

The study of the sediments as an aid to the earth historian: ELIOT BLACKWELDER, Department of geology, University of Illinois.

The growth of the Alaskan fur seal herd between 1912 and 1917: G. H. PARKER, United States Seal Investigation, 1914. Since 1912 the steady increase in the numbers of pups born, and of harem bulls and the decrease since 1913 of the average harem are most favorable signs in the growth of the herd. The one unfavorable feature during this period is the considerable increase in idle bulls in 1915, 1916 and especially in 1917. This in-

crease, which can be eventually checked, shows that active commercial killing should have been restored some years ago.

The destruction of tetanus antitoxin by chemical agents: W. N. Berg and R. A. Kelser, Pathological Division, Bureau of Animal Industry, Washington. The results indicate that tetanus antitoxin a substance of non-protein nature, but the stability of the antitoxin is so dependent upon that of the protein to which it is attached, that whenever the protein molecule is split, the antitoxin splits with it.

Tests for fluorine and tin in meteorites with notes on maskelynite and the effect of dry heat on meteoric stones: George P. Merrill, Department of Geology, United States National Museum, Washington.

Notes on isotopic lead: Frank Wigglesworth Clarke, United States Geological Survey, Washington. Investigations on the atomic weight of various forms of lead, and radioactive estimates of the age of minerals, are analysed for the purpose of throwing light upon isotopes and the structure of chemical elements.

The seventh number of Volume 4 contains the following articles:

On the representation of a number as the sum of any number of squares, and in particular of five or seven: G. H. Hardy, Trinity College, Cambridge, England.

The crystal structure of ice: Ancel St. John, Department of Physics, Lake Forest College. Ice is properly assigned to the hexagonal system, and consists of four interpenetrating triangular lattices, of which the fundamental spacings have been obtained.

Fringing reefs of the Philippine Islands: W. M. Davis, Department of Geology and Geography, Harvard University. An interpretation of recently published large-scale charts of the United States Coast and Geodetic Survey.

Dilation of the great arteries distal to partially occluding bands: William S. Halstead, Medical School, Johns Hopkins University. The relative amount of constriction required to give the most pronounced results has been determined, so that the author is able, in almost every instance, to produce the dilation, and a large amount of material thereby accumulated is analyzed.

On the correction of optical surfaces: A. A. Michelson, Ryerson Physical Laboratory, University of Chicago.

Edwin Bidwell Wilson
Mass. Institute of Technology,
Cambridge, Mass.

SPECIAL ARTICLES

INVESTIGATIONS ON THE IMBIBITION OF WATER BY GELATINE

Many investigators in both botany and zoology have recently been at work on the absorption of water by gelatine and other colloidal jellies and from their results have drawn some extremely interesting conclusions regarding physiological behavior. However as the published results accumulate many apparent discrepancies in actual experimental results are appearing. In an attempt to investigate some phases of imbibition by gelatine, I found difficulty in making my conclusions agree with those of previous workers and even in duplicating my own results. In the course of this work certain phenomena of the behavior of gelatine itself came to light and I am offering the following account of some of the preliminary work which I found necessary, in the hope that it may save other workers needless trouble and perhaps help to clear up some of the discrepancies referred to.

Various authors have emphasized the necessity for using material of a constant chemical composition, and for conducting all comparable tests at the same temperature, but the importance of an identical history of water-content and of water-loss seems to have been overlooked.

As was to be expected, the water-content of the gelatine at the beginning of the absorption, strongly influences the rate of water uptake. However, even when different lots of gelatine have the same water-content at the beginning of the absorption, their ability to

absorb water still depends upon their respective water-contents when they were made up, as Table I. shows. Several lots were made up to the concentrations given in the heading of the table, poured out on glass slabs, and allowed to lose water by evaporation at room temperature until tests showed that all had attained the same water-content (one gram gelatine to 0.17 grams water). Then pieces of the same size and form were placed in distilled water and their increase in thickness measured at intervals. The table shows that the lot which had the highest original percentage of water, increased in size most rapidly. That this meant a real difference in the amount of water absorbed was shown by the tests of the water-content at several stages. After 136 hours the pieces which were originally made up to contain 11 per cent. gelatine, had a water content of 98.4 grams per gram of gelatine. At the close of 160 hours the original 20 per cent. gelatine contained 178.0 grams of water per gram of gelatine, and the 33 per cent. gelatine, 100.0 grams of water per gram of gelatine.

The above results indicate that the evaporation of water from the gelatine influences any subsequent absorbing rate. The evaporational history of the gelatine used affects also the distribution of the increase in size among the several dimensions of any given piece, as is shown by the following conclusions which have been drawn from a large number of experiments. The tables to which reference is made contain fair samples of the many readings taken. The tests were made upon gelatine of several concentrations varying from 10 per cent. to 33 per cent. The pieces referred to were rectangular blocks $2.00 \times 0.35 \times 0.35$ cm.

1. When no appreciable amount of water has evaporated from the gelatine since it has set, blocks swell equally in length, thickness and breadth. This is true whether five minutes or forty-eight hours has elapsed since the setting. See Table II.

2. These blocks, when placed on a glass plate with their largest faces in a horizontal position, and allowed to lose water by evaporation at 18° to 30° C., shrink about twice as much in the two short dimensions as in the long one, shrinking being calculated as percentage of original size. See Table II.

3. When the blocks which had received the treatment mentioned in paragraph 2 above, were placed in water and allowed to swell the distribution of amount of increase among the three dimensions was in the same ratio that the shrinking had been. That is, the increase in size was about twice as great for the two short dimensions as for the long one. This distribution of increase continued for at least 60 hours after the gelatine had attained its original water-content. See Table II.

4. When blocks were cut from freshly made gelatine and hung on a thread with the long axes in a vertical position, where they were exposed to the air on all sides, the same distribution of decrease in size among the several dimensions took place as was described under paragraphs 2 and 3 above. The subsequent increase in size when blocks were placed in water also showed the same relation as formerly. That is, the shrinking and subsequent swelling were about twice as great in the two short dimensions as in the long one.

5. When gelatine was poured into a large dish or on to a glass slab and allowed to lose water by evaporation before pieces were cut, the decrease in thickness far exceeded the decrease in the other directions and the subsequent swelling in water followed the same proportions. For example, 15 per cent. gelatine when treated in this manner showed swelling to the following amounts: Height, 181 per cent., breadth 15 per cent., length 6 per cent. For the behavior of 33 per cent. gelatine see Table III. The more water lost by evaporation, the greater the difference in the swelling of the heighth and the other dimensions.

The above results indicate that the evaporation of water from the surface of gelatine jelly changes in some way the physical structure of the jelly. There has appeared thus far no evidence to determine whether these changes concern small group of molecules or much larger masses of gelatine. It may be merely that evaporation taking place more

rapidly in one direction than another causes an accumulation of a greater amount of gelatine in the planes perpendicular to that direction and hence more water can be absorbed and greater swelling take place. That this physical change was brought about by the evaporation of water and not by any natural change in the gelatine itself, was shown by comparative tests on the absorbing capacity of gelatine which was allowed to stand for twenty-four hours, with the absorbing capacity of gelatine which was exposed to the air for the same length of time. The first showed an equal swelling in all directions and the second the greatest swelling along the vertical axis (*i. e.*, the direction of greatest evaporation). It seemed at first that gravity might be a strong force in determining the direction of greatest deposition and hence of greatest swelling, but the experiments reported upon in paragraph 4 above show that it is the amount of surface exposed to evaporation that determines the direction of greatest shrinkage. Therefore, the vertical axis usually shows the greatest shrinkage or swelling because of the custom of pouring gelatine into dishes open only at the top, or onto slabs where the largest evaporating surface is on top. A further in-

TABLE I

Increase per cm. of original thickness of pieces of gelatine which were made up as follows: lot 1, 10 per cent. gelatine, *i. e.*, 1 gram of gelatine to 9 grams of water; lot 2, 13 per cent. gelatine; lot 3, 20 per cent. gelatine; lot 4, 33 per cent. gelatine. All lots were allowed to attain the same water-content by exposure to air at 18–30° C. They were then placed simultaneously into distilled water. The time column indicates the total times of immersion. Each number is an average of measurements taken on six pieces.

Time	Lot 1	Lot 2	Lot 3	Lot 4
16 hours	7.80	7.60	5.30	4.90
40 hours	9.30	9.30	6.50	5.20
64 hours	9.60	11.00	6.95	6.10
88 hours	11.00	—	7.30	6.80
112 hours	12.00	—	9.90	7.90
136 hours	13.20	—	10.50	8.60
160 hours	[1]	—	11.60	10.25

TABLE II

Change per cm. in size of rectangular blocks of gelatine (length = 2.00, height = 0.35, breadth = 0.35). (A) Blocks which have been tightly covered since time of setting, placed in distilled water. (B) Same blocks dried with filter paper and allowed to lose water by evaporation. (C) Same blocks again allowed to absorb water. Ratios are given in brackets below numbers.

Time	No. 1			No. 2			No. 3[2]			Notes
	Length	Height	Breadth	Length	Height	Breadth	Length	Height	Breadth	
24 hrs.	0.32 (1.0)	0.33 (1.0)	0.33 (1.0)	0.36 (1.0)	0.39 (1.1)	0.30 (0.8)	0.40 (1.0)	0.42 (1.0)	0.40 (1.0)	Increase. See (A) above.
3 hrs.	0.27 (1.0)	0.56 (2.1)	0.53 (2.0)	0.21 (1.0)	0.42 (2.0)	0.46 (2.2)	0.22 (1.0)	0.34 (1.5)	0.60 (2.7)	Decrease. See (B) above.
15 hrs.	0.25 (1.0)	0.47 (1.9)	0.53 (2.1)	0.26 (1.0)	0.55 (2.1)	0.52 (2.0)	0.24 (1.0)	0.38 (1.4)	0.58 (2.4)	Increase. See (C) above.
37 hrs.	0.31 (1.0)	0.61 (2.0)	0.66 (2.1)	0.32 (1.0)	0.55 (1.7)	0.66 (2.0)	0.27 (1.0)	0.43 (1.6)	0.49 (1.8)	Increase. See (C) above.
63 hrs.	0.35 (1.0)	0.63 (1.8)	0.74 (2.1)	0.36 (1.0)	0.53 (1.5)	0.67 (1.9)	0.31 (1.0)	0.47 (1.5)	0.45 (1.5)	Increase. See (C) above.

[1] Too soft for measurement.

[2] In the entire experiment 27 blocks were used. Nos. 1 and 2 represent the behavior of 26 of them. No. 3 is given for two reasons: (1) to show that although the shrinking was somewhat differently distributed among the three dimensions, still the relation between shrinking and subsequent swelling remains; (2) to give an idea of the variations which may be encountered when this method of measurement is used. Reference to the last will be made in a later paragraph.

vestigation into this matter might lead to a better insight into the mechanism of the swelling of gelatine. Whatever the mechanism of the change, it remains that always the greatest shrinkage subsequent swelling take place in axis perpendicular to the largest evaporating surface, regardless of the position of that surface.

In all experimentation on the absorbing capacity of gelatine it is, then, necessary to see that the following conditions prevail: (1) all the gelatine has the same original chemical composition; (2) the entire history of water-content from the time of setting to a jelly to the beginning of absorption must be the same for all the material; (3) if water loss by evaporation is to take place before absorption, then pieces or slabs of the same size and form must be used during the process; (4) if the increase is determined by the measurement of length of one dimension, then all measurements must be made on similar axes; (5) all the gelatine must have been exposed to the same temperature conditions.

TABLE III

Increase per cm. of three dimensions of rectangular blocks of gelatine (length = 0.69 cm., height = 0.15 cm., breadth = 0.30 cm.). Solution was made up to contain 33 per cent. of gelatine, poured onto a glass plate, allowed to lose water until nearly hard, cut into blocks and then allowed to absorb water. Ratios are given in brackets below percentages. Numbers refer to averages of two pieces each.

Total Time	3 Hrs.	127 Hrs.	151 Hrs.	175 Hrs.	202 Hrs.
Length . .	0.36	0.60	0.65	0.91	1.13
	(1.0)	(1.0)	(1.0)	(1.0)	(1.0)
Height . .	1.03	1.39	1.60	1.96	1.96
	(2.9)	(2.3)	(2.7)	(2.2)	(1.7)
Breadth .	0.30	0.42	0.69	0.88	0.88
	(0.8)	(0.7)	(1.1)	(1.0)	(0.8)

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REASON FOR THE HELPFUL EFFECT OF ALCOHOLIC BEVERAGES IN DIABETES, STATES OF DEPRESSION, AND CONVALESCENCE

IN diabetes the oxidative processes are defective, as is indicated by the fact that when sugar is ingested, it is not oxidized, as is normally done, but is excreted. This defective oxidation results in the accumulation of certain incompletely oxidized substances, acid in nature, thus giving rise to a condition of acidosis which is thought by many to be the cause of coma in the later stages of the disease. Neubauer,[1] Benedict and Török,[2] Allen and DuBois have shown that the administration of alcohol and alcoholic beverages, such as wine and whiskey, facilitates the oxidative processes in diabetes, thereby enabling the diabetic to burn sugar better with resulting decrease in acidosis and sugar excretion.

The present investigation was carried out in an attempt to determine how alcohol favors or facilitates oxidation in diabetes. It is known that oxidation in the body is increased by exercise or work, by the ingestion of food, by thyroid feeding, during the excitement stage of anesthesia, and in combat, and that oxidation is decreased by decreasing the amount of work or the amount of food ingested, during deep anesthesia and in phosphorus and chloroform poisoning. We found that when oxidation was increased in the ways enumerated, there occurred a corresponding increase in catalase, an enzyme in the tissues and possessing the property of liberating oxygen from hydrogen peroxide, due to the stimulation of the liver to an increased output of this enzyme into the blood, and that when oxidation was decreased, there occurred a corresponding decrease in catalase in the blood and tissues due to the decreased output of this enzyme from the liver and utilization in the tissues. From these results it was concluded that catalase is the enzyme in the tissues principally responsible for oxidation. Furthermore, we[3] showed that the catalase of the

[1] Neubauer, O., *Münchener med. Wochenschrift*, 1906, LIII., 791.

[2] Benedict and Török, *Zeitschrift für klinische Medizin*, 1906, LX., 329.

[3] Burge, *American Journal of Physiology*, 1916, XLI., 153; 1917; XLIII., 57, 545, 1917; XLIV., 290; SCIENCE, N. S., 1917, XLVI., 440. Burge, Kennedy and Neill, *American Journal of Physiology*, 1917, XLIII., 433. Kennedy and Burge, *Arch. Int. Med.*, 1917, XX., 892.

tissues was greatly decreased in pancreatic diabetes and accordingly suggested that the defective oxidation in this type of diabetes was due to the decrease in catalase. If the defective oxidation in diabetes is due to the decrease in the catalase of the tissues and if it can be shown that the administration of alcohol produces an increase in the catalase of the tissues due to the stimulation of the liver to an increased output of this enzyme into the blood, then it would seem probable that the helpful effect of alcohol in diabetes is due to the increase in catalase with resulting increase in oxidation.

Dogs were used in the investigation. The catalase in 0.5 c.c. of the blood of the animals was determined by adding this amount of blood to 50 c.c. of hydrogen peroxide in a bottle at 22° C. and as the oxygen gas was liberated, it was conducted through a rubber tube to an inverted burette previously filled with water. After the volume of gas thus collected in ten minutes had been reduced to standard atmospheric pressure, the resulting volume was taken as a measure of the amount of catalase in the 0.5 c.c. of blood. The material was shaken at a fixed rate of one hundred and eighty double shakes per minute during the determinations.

Twenty-five c.c. per kilo of body weight of 45 per cent. ethyl alcohol were introduced into the stomachs of the animals by means of a stomach tube. Previous to as well as at 15-minute intervals after the introduction of alcohol, the catalase in 0.5 c.c. of blood taken from the external jugular was determined. Fifteen minutes after the introduction of alcohol into the stomach, it was found that the catalase of the blood was increased by about 30 per cent., after 30 minutes by about 50 per cent., and after 45 minutes the catalase of the blood of some of the dogs was increased by as much as 100 per cent.

After etherizing other dogs the abdominal wall was opened and the catalase of the blood taken directly from the liver or from one of the hepatic veins as well as from the jugular was determined. It was found that the blood from the liver was richer in catalase by ten to fifteen per cent. than the blood from any other part of the body. This was taken to mean that there is a continuous output of catalase from the liver into the blood and that this catalase is taken to the tissues to be used presumably in the oxidative processes. After the introduction of the alcohol into the stomach of the animal, it was found that the catalase in the blood taken directly from the liver was increased much more rapidly than that taken from a systemic vein such as the jugular, hence the alcohol must have been stimulating the liver to an increased output of catalase and in this manner producing an increase in the catalase of the blood and hence of the tissues.

Alcohol was also administered to dogs rendered diabetic by the removal of the pancreas, and it was found that the catalase of the blood and hence of the tissues of these animals was increased. It is probable that the helpful effect of alcohol in states of depression and in convalescence as well as the exhilarating effect on normal subjects is due to the stimulation of the liver to an increased output of catalase with resulting increase in oxidation.

The conclusion is drawn that the administration of alcohol to diabetics is helpful because it stimulates the liver to an increased output of catalase which is carried by the blood to the tissues where it facilitates the oxidative processes with resulting increased oxidation of sugar and decreased acidosis.

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